APPENDIX E
KLEINFELDER HHRA REPORT

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A Report Prepared for:

City of Los Angeles
Department of Public Works/Bureau of Engineering
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Los Angeles, California 90014-1911

HUMAN HEALTH RISK ASSESSMENT
PLAYA VISTA DEVELOPMENT
LOS ANGELES, CALIFORNIA

Kleinfelder Job No. 58-950301-001

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February 6, 2001

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EXECUTIVE SUMMARY

Kleinfelder conducted a human health risk assessment of chemicals present in soil gas on the Playa Vista development in Los Angeles, California. A widely-used computer model approved and published by U.S. EPA (EQM 1997) for subsurface vapor intrusion into buildings was used to assess potential exposures of future residents of the Playa Vista development to benzene, ethylbenzene, toluene, xylenes (collectively known as the BTEX compounds), and hydrogen sulfide vapors that may migrate from subsurface soil to indoor air. Migration of these vapors into indoor spaces constitutes a potential inhalation exposure. The computer model was used to estimate the excess lifetime cancer risk and the noncancer hazard that may be associated with inhalation of organic soil vapors that migrate aboveground from the subsurface. Only the inhalation exposure pathway was quantitatively evaluated because the chemicals of concern are present as vapors and other exposure pathways, such as skin contact, do not pose a hazard at the concentrations measured.

CHEMICALS OF CONCERN

The soil gas survey data upon which the model runs were based were developed from the results of three surveys conducted in 1999 and 2000 on the subject property (ETI 2000; CDM 2000a; CDM 2000b). Measurable levels of methane, hydrogen sulfide, and BTEX compounds have been detected in soil gas samples collected in these surveys.

The three soil gas surveys evaluated the presence of methane, which was measured at the survey depths of 4 to 4.5 feet below ground surface at concentrations of up to 891,543 ppmv. The health hazards associated with methane were not quantified in this risk assessment because methane does not cause systemic effects like lung, liver, or kidney damage. At high concentrations, methane is an asphyxiant. Concentrations of methane much lower than those of concern for asphyxiation pose an explosion hazard. Therefore, methane mitigation measures required for this project by the City of Los Angeles, Department of Building and Safety are more than adequate to address the potential health hazards associated with this gas.

To: Peter Hayden, Kleinfelder Inc. Jan. 16, 2001
From: Mike Mulhern, GED, City of Los Angeles

DRAFT

Comments on Jan. 4, 2001 Human Health Risk Assessment, Playa Vista Development

- The corrections/additions will constitute a "FINAL DRAFT", please label as such.
- On Page 1 of Exec. Summary, end of first paragraph, would it be better to replace "was evaluated" with "was quantified"? This would be more in line with the next paragraph, and show that you did evaluate these pathways but did not need to quantify them or study further. Was injestion also considered/evaluated?
- Page 1 , last paragraph, the "30 years" will be a red flag. Discuss and clarify the 30-yr exposure, 70-year average lifetime and say that it is consistent with CalEPA and DTSC policy. Also see Barb's comments for this item.
- Page 2 of Exec. Summary, 3rd Paragraph-Page 9 of 10 of the test infers that these people here you are evidently excluding are adequately protected and you do not recommend further investigation. I would either leave out this whole paragraph from the Exec. Summary or discuss how adult exposure to indoor air is the most conservative (residential child exposure to indoor/outdoor air is less, etc). This whole paragraphs invites an air strike.
- Page 3, 3rd bullet item, I would include the words "for all structures of the project" after the words "building codes"
- Last bullet item of page 3, are children protected, using the 30-yr exposure because adult inhalation rates are greater? What about childrens' sensitivities?
- Last paragraph of Page 3, insert the work "respectively" after "3X10-8" and before "based on the..."

- Page 1 of 10 (text), are there other models besides Johnson & Ettinger that could be considered, or is it the only one for CALEPA and the real gold standard? Section 2.2 discusses some model uncertainties. Are there any Achille's Heels of the model, any fatal flaws that may apply to this project?
- Page 6 of 10, What SCS Soil type was used?
- Page 8-See Barb's comments on 70-year averaging.

We are awaiting the Methane gas Report.

See you tomorrow @ the Reg Board

MEM20/PlayaVistaHRAkleinf.rev

Of the more than 1,000 soil gas samples analyzed for BTEX compounds and hydrogen sulfide, benzene and ethylbenzene were positively detected in less than 5% of the samples. Chemicals detected in less than 5% of the samples analyzed do not necessarily warrant evaluation in a risk assessment and, with regulatory agency approval, can be omitted from a risk assessment (EPA 1989). However, to ensure that risk calculations performed in support of this analysis are conservative, the cancer risk and noncancer hazard that may be associated with chemicals detected in fewer than 5% of the samples were quantified and incorporated into the total cancer risk and noncancer hazard estimated for the site.

EXPOSURE ASSUMPTIONS

The estimates of cancer risk and noncancer hazard developed in this risk assessment were based on an individual who lives on the subject site 24 hours per day, 350 days per year, for 30 years, averaged over a 70 year period (U.S. EPA 1989; OEHHA 1994; and DTSC 1999) and is exposed to the chemicals of concern that have migrated above ground. Separate estimates of cancer risk and noncancer hazard were developed from the average and the maximum soil gas concentration of each of the chemicals of concern.

This human health risk assessment is based on EPA's *reasonable maximum exposure* (RME) assumptions (EPA 1989). The RME is defined as the highest exposure that is reasonably expected to occur at a site. The intent of the RME is to estimate a conservative exposure case (i.e., well above the average case) that is still within the range of possible exposures. The key RME assumptions applied in this risk assessment are as follows:

- Exposure frequency – 350 days per year, 24 hours per day, which assumes that the receptor does not leave the home except for a two-week vacation each year;
- Exposure duration – 30 years (U.S. EPA 1989; OEHHA 1994; and DTSC 1999), which represents the 90th percentile based on the 1990 census (EPA 1997);
- Exposures to carcinogens were averaged over a 70 year lifetime (U.S. EPA 1989; OEHHA 1994; and DTSC 1999).

- Exposure point concentration – includes the maximum measured concentration although the maximum concentration occurred at only one of 1,155 locations sampled. For benzene (the chemical that poses the greatest health hazard based on this risk assessment) the maximum concentration was almost four times greater than the next highest concentration and benzene was detected in fewer than 5% of the 1,155 samples analyzed;
- Protective of children – longer exposure duration (30 years vs. 6 years) and greater magnitude of exposure (inhalation rate of 20 m^3/day vs. 10 m^3/day) were assumed;
- Cancer risk and noncancer hazard were quantified for chemicals present in less than 5% of samples analyzed (i.e., benzene and ethylbenzene). Chemicals detected with low frequency do not necessarily require evaluation. With regulatory agency approval, chemicals detected in less than 5% of samples analyzed can be omitted from a risk assessment; and
- This risk assessment evaluated all soil vapor measurements, regardless of the potential source of the vapors (i.e., thermogenic releases, near-surface releases of contaminants in soils, or volatilization of contaminants in groundwater).
- The California cancer risk factor for benzene, which is more health protective than the U.S. EPA Cancer risk factor, was used in this risk assessment.
- No mitigation measures (e.g., vapor barriers, vapor collection systems) were incorporated into the assessment of health risk.

Vapor migration to outdoor air was not evaluated because migration to indoor air poses a more significant hazard. The indoor air hazard estimated in this risk assessment was below regulatory limits, therefore, an evaluation of outdoor air was not necessary. Commercial exposure was not evaluated because the exposed individuals spend more time at home than they do at work; therefore, the potential health risks associated with residential exposure exceeds those of commercial exposure.

CANCER RISK THRESHOLD

Cancer risk was quantified as the excess lifetime cancer risk, which is the probability that an individual exposed, under the conditions defined in the risk assessment, to the chemicals of concern will develop cancer as a result of that exposure over and above the background rate of cancer in the US population. The background rate of cancer in the US is about 1 in 3 (American

Cancer Society 1993). Therefore, of the roughly 300,000,000 citizens of the US, 100,000,000 can expect to develop some form of cancer at some time in their lives. If the entire population of the US were to reside on a site where, due to chemical contamination, the excess lifetime cancer risk was 1×10^{-6} (1 chance in 1,000,000), then an additional 300 citizens might develop some form of cancer as a result, and the total number of cancer cases would be 100,000,300.

For the development of cancer, the California Office of Environmental Health Hazard Assessment (OEHHA) has developed "No Significant Risk Levels" for carcinogens that are based on an excess lifetime cancer risk of 1×10^{-5} (OEHHA 1994). EPA has recommended that a cancer risk range of 10^{-6} to 10^{-4} be used for making decisions about whether further investigation or remediation is warranted (EPA 1986). Thus, when the cumulative cancer risk for a given site is less than 1×10^{-6}, further investigation and remediation are generally not warranted. A cumulative cancer risk of 1×10^{-6} means that there is a 1 in 1,000,000 chance that cancer will develop in an exposed individual at some time in their life as a result of exposure to the chemicals of concern. Of the chemicals of concern evaluated in this risk assessment, only benzene is classified as a carcinogen.

NONCANCER HAZARD THRESHOLD

Noncancer hazard is quantified based on an estimated dose to which a resident may be exposed, under the conditions defined in the risk assessment, compared to a reference dose (RfD) developed by the U.S. EPA. The RfD is a dose that is not expected to result in adverse health effects. If the ratio of the estimated dose and the RfD is less than 1.0, then adverse health effects are not expected. The ratio of the estimated dose and the RfD is called the hazard quotient.

For noncancer hazards, EPA has recommended a hazard quotient of 1 as the point of departure for making decisions about further investigation or remediation. The hazard quotient is the result of dividing an estimated intake of a chemical through soil ingestion, inhalation, or dermal contact, or all three by a daily dose of a chemical that is expected to be without harm, the reference dose. When total intake exceeds the reference dose, the hazard quotient is greater than 1 and there is an increased likelihood that noncancerous adverse health effects will develop in the exposed population.

RESULTS AND CONCLUSIONS

Based on the risk assessment described in this report, the cancer risk that may be associated with exposure to soil gas (BTEX and hydrogen sulfide) that has migrated aboveground is 7×10^{-9} for average soil gas concentrations and 1×10^{-7} for maximum concentrations. These cancer risk estimates are well below the 1×10^{-6} cancer risk that DTSC, EPA, and other regulatory agencies consider to be acceptable and does not require further investigation or remediation.

The noncancer hazard quotient was estimated to be 0.0001 for average soil gas concentrations and 0.051 for maximum concentrations. DTSC and EPA consider a noncancer hazard quotient below 1.0 to be acceptable and does not require further investigation or remediation.

On the basis of these risk assessment results, Kleinfelder recommends that no further investigation or remediation are necessary to adequately protect commercial workers; adult and child residents; and school children from soil gas vapors that may migrate from the subsurface environment into the outdoor air or structures built on the subject property.

1.0 INTRODUCTION

A human health risk assessment was conducted to evaluate the potential exposure of hypothetical future residents of the Playa Vista development to benzene, ethylbenzene, toluene, xylenes, and hydrogen sulfide vapors that may migrate aboveground from subsurface soil. Migration of these vapors into indoor spaces constitutes a potential inhalation exposure and may pose a health hazard. An EPA-approved computer model, the Johnson and Ettinger Model, was used to estimate the excess lifetime cancer risk and the noncancer hazard that may be associated with inhalation of organic vapors that migrate from the subsurface into a home.

1.1 RISK ASSESSMENT PURPOSE AND PROCESS

A risk assessment helps to answer two key questions about a site that has been contaminated by chemical releases: does the contamination pose a hazard to human health, and, if so, what level of hazard does it pose? To answer these questions the risk assessor:

- Identifies chemicals of concern,
- Evaluates how a receptor group may come into contact with those chemicals,
- Estimates the magnitude of exposure during that contact, and based on what is known about the toxicity of the chemicals of concern,
- Seeks to qualitatively and quantitatively estimate the level of hazard posed.

Simplifying assumptions are made throughout the development of the risk assessment. These assumptions tend to result in an overestimate of the actual risk at a given site. Therefore, it is highly unlikely that the risk assessment will result in a "false negative." That is to say, it is highly unlikely that an unacceptable health hazard would be overlooked.

The exposure scenario evaluated in this risk assessment was based on highly conservative and health-protective assumptions. The maximally-exposed individual was assumed to be a future onsite resident who will live in a home constructed on the subject site at the location of the highest concentrations of the chemicals of concern for 350 days per year for 30 years averaged over a 70 year period. (U.S. EPA 1989, 1997; OEHHA 1994; and DTSC 1999). These assumptions are also protective of children because they are based on an adult exposure period that is longer (30 years vs. 6 years) and of greater magnitude (inhalation rate of 20 m^3/day vs. 10 m^3/day) than those for a child. In other words, the child exposure used in these analyses was a factor of 10 higher than actual exposure conditions.

The onsite resident exposure scenario is also likely to be a substantial overestimation of the true residential exposure situation. The onsite resident was assumed to remain in a single location (where the highest concentrations of the chemicals of concern occur) for 350 days per year over 30 years, averaged over 70 years (U.S. EPA 1989; OEHHA 1994; and DTSC 1999). Furthermore, exposures were modeled based on the assumption that the maximum source vapor concentration occurred across the site although the maximum concentration occurred at only one of the 1,155 locations sampled. For example, the cancer risk that may be associated with the maximum soil gas concentration of benzene was based on the assumption that the maximum concentration of benzene occurred throughout the site, not only at the location where that measurement was made.

Of the more than 1,000 soil gas samples analyzed for BTEX compounds and hydrogen sulfide, benzene and ethylbenzene were positively detected in less than 5% of the samples. Chemicals detected in less than 5% of the samples analyzed do not necessarily warrant evaluation in a risk assessment and, with regulatory agency approval, can be omitted from a risk assessment (EPA 1989). However, to ensure that risk calculations performed in support of this analysis are conservative, the cancer risk and noncancer hazard that may be associated with chemicals detected in fewer than 5% of the samples were quantified and incorporated into the total cancer risk and noncancer hazard estimated for the site. In spite of these conservative, health-protective, assumptions, the cancer risk and noncancer hazard based on the average and maximum soil gas concentrations are much less than EPA's point of departure discussed below.

The quantitative assessment criteria applied in a human health risk assessment are based on the probability that cancer will develop in an exposed population or the likelihood that noncancerous effects will develop in that population as a result of exposure to the chemicals of concern. For the development of cancer, the California Office of Environmental Health Hazard Assessment (OEHHA) has developed "No Significant Risk Levels" for carcinogens that are based on an excess lifetime cancer risk of 1×10^{-5} (OEHHA 1994). EPA has recommended that a cancer risk range of 10^{-6} to 10^{-4} be used for making decisions about whether further investigation or remediation is warranted (EPA 1986). Thus, when the cumulative cancer risk for a given site is less than 1×10^{-6}, further investigation and remediation are generally not warranted. A cumulative cancer risk of 1×10^{-6} means that there is a 1 in 1,000,000 chance that cancer will develop in an exposed individual at some time in their life as a result of exposure to the chemicals of concern. To put this cancer risk in perspective, the background rate of cancer in the United States is about 1 in 3 (American Cancer Society 1993). Therefore, of the roughly 300,000,000 citizens of the United States, 100,000,000 can expect to develop some form of cancer at some time in their lives. If the entire population of the United States were to reside on a site where, due to chemical contamination, the excess lifetime cancer risk was 1×10^{-6}, then an additional 300 citizens might develop some form of cancer as a result and the total number of cancer cases would be 100,000,300. Of the chemicals of concern evaluated in this risk assessment, only benzene is classified as a carcinogen.

For noncancer hazards, EPA has recommended a hazard quotient of 1 as the point of departure for making decisions about further investigation or remediation. The hazard quotient is the result of dividing an estimated intake of a chemical through soil ingestion, inhalation, or dermal contact, or all three by a daily dose of a chemical that is expected to be without harm, the reference dose. When total intake exceeds the reference dose, the hazard quotient is greater than 1 and there is an increased likelihood that noncancerous adverse health effects will develop in the exposed population.

The three soil gas surveys also evaluated the presence of methane, which was present at the survey depths of 4 to 4.5 feet below ground surface at concentrations of up to 891,543 ppmv. The health hazards associated with methane were not quantified in this risk assessment because it is a simple asphyxiant without any systemic effects like lung, liver, or kidney damage. An asphyxiant simply replaces oxygen in breathable air. The health hazards associated with methane can be successfully managed with engineering controls, including vapor barriers and collection systems that are required in the building code of the City of Los Angeles.

1.2 THE JOHNSON AND ETTINGER MODEL

Johnson and Ettinger (1991, cited in EQM 1997) introduced a screening-level model which incorporates both convective and diffusive mechanisms for estimating the transport of contaminant vapors emanating from groundwater into indoor spaces located directly above or near the source of contamination. Johnson and Ettinger reported that the results of the model were in qualitative agreement with published experimental case histories and in good qualitative and quantitative agreement with detailed three-dimensional numerical modeling of radon transport into houses (Loureiro, et al. 1990, cited in EQM 1997).

The Johnson and Ettinger Model is a one-dimensional analytical solution to convective and diffusive vapor transport into indoor spaces and provides an estimated attenuation coefficient that relates the vapor concentration in the indoor space to the vapor concentration at the source of contamination. The model can provide a steady-state solution to vapor transport (infinite or nondiminishing source) and a quasi-steady-state solution (finite or diminishing source). Inputs to the model include chemical properties of the contaminants, saturated and unsaturated zone soil properties, and structural properties of the building.

2.0 JOHNSON AND ETTINGER MODEL INPUTS

The Johnson and Ettinger model requires several input variables for estimating excess lifetime cancer risk and noncancer hazard. Table 2-1 provides a summary of the model inputs used to evaluate the health hazards that may be associated with benzene, ethylbenzene, toluene, xylenes, and hydrogen sulfide present as soil gas at the Playa Vista site. The Data Entry Numbers identified in Table 2-1 correspond to the inputs in the model data entry sheets (Appendix A). Land use at the subject site was assumed to be residential, therefore, the model inputs for exposure duration and exposure frequency were consistent with California Department of Toxic Substances Control (DTSC) (DTSC 1999) and U.S. EPA default assumptions for a residential exposure scenario (EPA 1989, 1997).

TABLE 2-1
SUMMARY OF JOHNSON AND ETTINGER MODEL ASSUMPTIONS - SOIL

Data Entry Number	Parameter	Comment
1	Depth below grade to bottom of enclosed space floor	15 cm, default value for slab-on-grade construction.
2	Depth below grade to location of soil gas measurement	*Soil* – Four feet (122 cm) based on shallowest soil sampling depth.
3	Average soil temperature	18°C, estimated for Southern California (EQM 1997).
4	Vadose zone SCS soil type	Soil type "silty clay" selected based on boring log observations.
5	Vadose zone soil dry bulk density	1.5 g/cm^3, default value recommended in EQM (1997).
6	Vadose zone soil total porosity	0.43, default value recommended in EQM (1997).
7	Vadose zone soil water-filled porosity	0.3 cm^3/cm^3, default value recommended in EQM (1997).
8	Vadose zone soil organic carbon fraction	0.002 (unitless), default value recommended in EQM (1997).
9	Averaging time for carcinogens	70 years, U.S. EPA (1997, 1989), OEHHA (1994), and DTSC (1999)
10	Averaging time for noncarcinogens	30 years (residents), U.S. EPA (1997, 1989), OEHHA (1994), and DTSC (1999)
11	Exposure duration	30 years (residential), U.S. EPA (1997), OEHHA (1994), and DTSC (1999)

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TABLE 2-1 (Continued)

SUMMARY OF JOHNSON AND ETTINGER MODEL ASSUMPTIONS - SOIL

Data Entry Number	Parameter	Comment
12	Exposure frequency	350 days per year (residential), U.S. EPA (1997)
13	Target risk for carcinogens	1 x 10^{-6}, considered as the *de minimis* standard by U.S. EPA.
14	Target hazard quotient for noncarcinogens	1.0, considered as the *de minimis* standard by U.S. EPA.

In all cases, the most health-protective model inputs were selected or, lacking site-specific information, the default model inputs recommended in EQM (1997) were selected. This approach represents a reasonable upper-bound on the range of values. Therefore, the risk assessment results are overly protective of human health.

2.1 SOIL GAS ANALYTICAL DATA

This risk assessment is based on soil gas data published in three reports of soil gas surveys conducted across the Playa Vista site in 1999 and 2000. The survey approach, areas of concern, and results are discussed below.

2.1.1 Exploration Technologies, Inc. (ETI), April 17, 2000.

ETI designed and supervised a shallow soil vapor survey in Tracts 01, 02, and 03 (First Phase) of the proposed Playa Vista development. The survey consisted of 812 sampling locations on a 100-foot staggered grid and soil vapor samples were collected from a depth of four-feet below ground surface (bgs). The vapor samples were analyzed for benzene, ethylbenzene, toluene, m/p-xylenes, and o-xylene (collectively known as the BTEX compounds), and hydrogen sulfide (H_2S). Generally, very low levels of BTEX and H_2S were observed in all samples collected: Benzene was detected in four of 721 samples (maximum = 3.85 ppmv). The next highest concentration of benzene was 1.05 ppmv. Toluene was detected in 199 of 721 samples (maximum = 5.09 ppmv), ethylbenzene in one of 721 samples (maximum = 1.5 ppmv), and total xylenes in 104 of 721 samples (maximum = 3.12 ppmv). H_2S was detected in 494 of 769 samples at a maximum concentration of 41 ppmv. ETI concluded that the source of BTEX and H_2S observed is near surface contamination and is not necessarily directed associated with methane observed at the site (ETI 2000).

2.1.2 Camp Dresser & McKee, Inc. (CDM), November 2, 2000.

CDM (2000a) reported the results of a shallow soil gas survey conducted in Areas A, B, C, and D (Phase 2 Portion) of the Playa Vista Development. The vapor samples were analyzed for BTEX compounds and H_2S. The survey consisted of 215 sampling locations on a 300-foot grid in Areas A, B, and C, and a 500-foot grid in Area D. Samples were collected from a depth of 4.5 feet bgs. BTEX and H_2S were infrequently detected and when present were measured at relatively low concentrations: Benzene was detected in two of 215 samples (maximum = 1.05 ppmv), toluene was detected in 15 samples (maximum = 0.3 ppmv), ethylbenzene in five samples (maximum = 1.11 ppmv), and total xylenes in nine samples (maximum = 0.92 ppmv). H_2S was detected in 31 of 215 samples at a maximum concentration of 0.023 ppmv.

2.1.3 Camp Dresser & McKee, Inc. (CDM), November 9, 2000.

CDM (2000b) reported the results of a shallow soil gas survey conducted in Tracts 49104-01, -03, -05, and -06 of the Playa Vista Development. The samples were analyzed for BTEX compounds and H_2S. The survey consisted of 192 sampling locations and samples were collected from a depth of four feet bgs. BTEX and H_2S were infrequently detected and when present were measured at relatively low concentrations: Benzene was detected in 28 of 192 samples (maximum = 0.18 ppmv), and low concentrations (less than 1.08 ppmv) of toluene, ethylbenzene, and total xylenes were also measured. H_2S was detected in 49% of 215 samples. The maximum concentration of H_2S was 2.1 ppmv and the average concentration was 0.008 ppmv.

2.1.4 Preparation of Soil Gas Data for Risk Assessment

The volume of data and the thoroughness of the grid sampling yield a dataset that is more than adequate for the development of a human health risk assessment. The soil gas data generated in the three studies cited above were combined into a single dataset based on the similar methodologies for collection and analysis that were applied. From these data the average and maximum soil gas concentrations of each analyte were developed for use in this risk assessment and provide the basis for the calculation of cancer risk and noncancer hazard.

Because the Johnson and Ettinger Model estimates cancer risk and noncancer hazard from a calculated source vapor concentration that is based on a soil or groundwater concentration entered by the model user, Kleinfelder estimated soil concentrations of the chemicals of concern that would yield a source vapor concentration equivalent to the average and maximum concentrations measured in the three soil gas surveys. The source vapor concentrations entered into the model are summarized in Table 2-2.

Table 2-2

Source Vapor Concentrations for the Chemicals of Concern

Chemical	Average Vapor Concentration (ug/m^3)	Maximum Vapor Concentration (ug/m^3)
Benzene	766	12,300
Ethylbenzene	1,261	6,530
Toluene	675	19,095
m/p-Xylenes	1,087	13,580
o-Xylenes	696	6,043
Hydrogen Sulfide (H_2S)	153	57,148

The source vapor concentrations summarized in Table 2-2 were calculated using the Johnson and Ettinger Model and can be found for each chemical in Appendix A as entry number 15 in the model spreadsheets. The data from which the source vapor concentrations were developed are summarized in Appendix B.

3.0 RISK ASSESSMENT RESULTS AND CONCLUSIONS

The output of the Johnson and Ettinger Model Spreadsheet is an estimated cancer risk or noncancer hazard based on the soil or groundwater concentration entered for a given chemical of concern. For this risk assessment, the cancer risk and noncancer hazard estimates generated with the Johnson and Ettinger Model are summarized in Table 3-1. The Johnson and Ettinger Model spreadsheets, from which the information in Table 3-1 was generated, are presented in Appendix A.

TABLE 3-1
SUMMARY OF INHALATION CANCER RISK AND NONCANCER HAZARD FOR SOIL GAS CHEMICALS OF CONCERN, PLAYA VISTA DEVELOPMENT

Chemical	Estimated Cancer Risk		Estimated Noncancer Hazard	
	Average[a]	Maximum[b]	Average	Maximum
Benzene	7×10^{-9}	1×10^{-7}	9.7E-6	1.6E-4
Ethylbenzene	NA[c]	NA[c]	9.4E-7	4.8E-6
Toluene	NA[c]	NA[c]	1.3E-6	3.6E-5
m/p-Xylenes	NA[c]	NA[c]	1.2E-7	1.5E-6
o-Xylenes	NA[c]	NA[c]	7.5E-8	6.5E-7
Hydrogen Sulfide (H_2S)	NA[c]	NA[c]	1.4E-4	5.1E-2
TOTALS	**7×10^{-9}**	**1×10^{-7}**	**0.0001**	**0.051**

[a] Average indicates that the cancer risk or noncancer hazard presented is based on the average soil gas concentration measured on the subject site.
[b] Maximum indicates that the cancer risk or noncancer hazard presented is based on the maximum soil gas concentration measured on the subject site.
[c] Indicates that this chemical is not a known or suspected carcinogen, therefore, a cancer risk was not estimated.

Based on a comparison of the cancer risk estimates presented in Section 3.0 to the OEHHA and EPA acceptable cancer risk ranges (1×10^{-6} to 1×10^{-4}), the chemicals of concern present as soil gas (BTEX compounds and H_2S) do not pose an unacceptable cancer risk. Similarly, comparison of the noncancer hazard quotients for the chemicals of concern to the generally accepted noncancer hazard quotient standard of 1.0 indicates that the noncancer hazard that may be associated with the chemicals of concern is well below the acceptable level. It should be noted that these insignificant risks would be further reduced through potential soil and groundwater remediation activity at the site, use of vapor barriers, and other site mitigation measures required by the California Regional Water Quality Control Board, City of Los Angeles Fire Department, City of Los Angeles Department of Building and Safety, and other appropriate agencies. Furthermore, the HRA evaluated the effects of chemicals of concern found in fewer than 5% of the more than 1,000 samples analyzed. Chemicals detected in less than 5% of the samples analyzed do not necessarily warrant evaluation in a risk assessment and, with regulatory agency approval, can be omitted from a risk assessment (EPA 1989).

On the basis of these risk assessment results, Kleinfelder recommends that no further investigation or remediation are necessary to adequately protect commercial workers; adult and child residents; and school children from soil gas vapors that may migrate from the subsurface environment into the outdoor air or structures built on the subject property.

4.0 REFERENCES

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DATA ENTRY SHEET

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CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (μg/kg)	Chemical
71432	1.515	Benzene

ENTER Depth below grade to bottom of enclosed space floor, L_F (15 or 200 cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Average soil temperature, T_S (°C)	ENTER Vadose zone SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined vadose zone soil vapor permeability, k_v (cm²)
1	2	3	4		
15	121.92	18	SIC		

ENTER Vadose zone soil dry bulk density, ρ_b^A (g/cm³)	ENTER Vadose zone soil total porosity, n^V (unitless)	ENTER Vadose zone soil water-filled porosity, θ_w^V (cm³/cm³)	ENTER Vadose zone soil organic carbon fraction, f_{oc}^V (unitless)
5	6	7	8
1.5	0.43	0.3	0.002

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
9	10	11	12	13	14
70	30	30	350	1.0E-06	1

Used to calculate risk-based soil concentration.

RESULTS SHEET

RISK-BASED SOIL CONCENTRATION CALCULATIONS:

Indoor exposure soil conc., carcinogen (μg/kg)	Indoor exposure soil conc., noncarcinogen (μg/kg)	Risk-based indoor exposure soil conc., (μg/kg)	Soil saturation conc., C_{sat} (μg/kg)	Final indoor exposure soil conc., (μg/kg)
NA	NA	NA	1.67E+05	NA

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
NA	1.5E-06

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CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (μg/kg)	Chemical
95476	4.56	o-Xylene

ENTER Depth below grade to bottom of enclosed space floor, L_F (15 or 200 cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Average soil temperature, T_S (°C)	ENTER Vadose zone SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined vadose zone soil vapor permeability, k_v (cm²)
15	121.92	18	SIC		

ENTER Vadose zone soil dry bulk density, ρ_b^A (g/cm³)	ENTER Vadose zone soil total porosity, n^V (unitless)	ENTER Vadose zone soil water-filled porosity, θ_w^V (cm³/cm³)	ENTER Vadose zone soil organic carbon fraction, f_{oc}^V (unitless)
1.5	0.43	0.3	0.002

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1

Used to calculate risk-based soil concentration.

KLEINFELDER

RESULTS SHEET

RISK-BASED SOIL CONCENTRATION CALCULATIONS:

Indoor exposure soil conc., carcinogen (µg/kg)	Indoor exposure soil conc., noncarcinogen (µg/kg)	Risk-based indoor exposure soil conc., (µg/kg)	Soil saturation conc., C_{sat} (µg/kg)	Final indoor exposure soil conc., (µg/kg)
NA	NA	NA	5.82E+05	NA

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
7.2E-09	9.7E-06
15	17

DATA ENTRY SHEET

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CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (μg/kg)	Chemical
71432	24.3	Benzene

ENTER Depth below grade to bottom of enclosed space floor, L_F (15 or 200 cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Average soil temperature, T_S (°C)	ENTER Vadose zone SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined vadose zone soil vapor permeability, k_v (cm²)
15	121.92	18	SIC		

ENTER Vadose zone soil dry bulk density, ρ_b^A (g/cm³)	ENTER Vadose zone soil total porosity, n^V (unitless)	ENTER Vadose zone soil water-filled porosity, θ_w^V (cm³/cm³)	ENTER Vadose zone soil organic carbon fraction, f_{oc}^V (unitless)
1.5	0.43	0.3	0.002

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1

Used to calculate risk-based soil concentration.

RESULTS SHEET

RISK-BASED SOIL CONCENTRATION CALCULATIONS:

Indoor exposure soil conc., carcinogen (μg/kg)	Indoor exposure soil conc., noncarcinogen (μg/kg)	Risk-based indoor exposure soil conc., (μg/kg)	Soil saturation conc., C_{sat} (μg/kg)	Final indoor exposure soil conc., (μg/kg)
NA	NA	NA	5.82E+05	NA

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
1.2E-07	1.6E-04

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CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (μg/kg)	Chemical
108883	2.041	Toluene

ENTER Depth below grade to bottom of enclosed space floor, L_F (15 or 200 cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Average soil temperature, T_S (°C)	ENTER Vadose zone SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined vadose zone soil vapor permeability, k_v (cm²)
15	121.92	18	SIC		

ENTER Vadose zone soil dry bulk density, ρ_b^A (g/cm³)	ENTER Vadose zone soil total porosity, n^V (unitless)	ENTER Vadose zone soil water-filled porosity, θ_w^V (cm³/cm³)	ENTER Vadose zone soil organic carbon fraction, f_{oc}^V (unitless)
1.5	0.43	0.3	0.002

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1

Used to calculate risk-based soil concentration.

RESULTS SHEET

RISK-BASED SOIL CONCENTRATION CALCULATIONS:

Indoor exposure soil conc., carcinogen (μg/kg)	Indoor exposure soil conc., noncarcinogen (μg/kg)	Risk-based indoor exposure soil conc., (μg/kg)	Soil saturation conc., C_{sat} (μg/kg)	Final indoor exposure soil conc., (μg/kg)
NA	NA	NA	3.05E+05	NA

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
NA	1.3E-06

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CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (μg/kg)	Chemical
108883	57.6	Toluene

ENTER Depth below grade to bottom of enclosed space floor, L_F (15 or 200 cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Average soil temperature, T_S (°C)	ENTER Vadose zone SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined vadose zone soil vapor permeability, k_v (cm²)
15	121.92	18	SIC		

ENTER Vadose zone soil dry bulk density, ρ_b^A (g/cm³)	ENTER Vadose zone soil total porosity, n^V (unitless)	ENTER Vadose zone soil water-filled porosity, θ_w^V (cm³/cm³)	ENTER Vadose zone soil organic carbon fraction, f_{oc}^V (unitless)
1.5	0.43	0.3	0.002

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1

Used to calculate risk-based soil concentration.

RESULTS SHEET

RISK-BASED SOIL CONCENTRATION CALCULATIONS:

Indoor exposure soil conc., carcinogen (µg/kg)	Indoor exposure soil conc., noncarcinogen (µg/kg)	Risk-based indoor exposure soil conc., (µg/kg)	Soil saturation conc., C_{sat} (µg/kg)	Final indoor exposure soil conc., (µg/kg)
NA	NA	NA	3.05E+05	NA

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
NA	3.6E-05

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CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (μg/kg)	Chemical
100414	5.45	Ethylbenzene

ENTER Depth below grade to bottom of enclosed space floor, L_F (15 or 200 cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Average soil temperature, T_S (°C)	ENTER Vadose zone SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined vadose zone soil vapor permeability, k_v (cm^2)
15	121.92	18	SIC		

ENTER Vadose zone soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Vadose zone soil total porosity, n^V (unitless)	ENTER Vadose zone soil water-filled porosity, θ_w^V (cm^3/cm^3)	ENTER Vadose zone soil organic carbon fraction, f_{oc}^V (unitless)
1.5	0.43	0.3	0.002

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1

Used to calculate risk-based soil concentration.

RESULTS SHEET

RISK-BASED SOIL CONCENTRATION CALCULATIONS:

Indoor exposure soil conc., carcinogen (μg/kg)	Indoor exposure soil conc., noncarcinogen (μg/kg)	Risk-based indoor exposure soil conc., (μg/kg)	Soil saturation conc., C_{sat} (μg/kg)	Final indoor exposure soil conc., (μg/kg)
NA	NA	NA	1.67E+05	NA

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
NA	7.5E-08

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CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (μg/kg)	Chemical
95476	39.6	o-Xylene

ENTER Depth below grade to bottom of enclosed space floor, L_F (15 or 200 cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Average soil temperature, T_S (°C)	ENTER Vadose zone SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined vadose zone soil vapor permeability, k_v (cm^2)
15	121.92	18	SIC		

ENTER Vadose zone soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Vadose zone soil total porosity, n^V (unitless)	ENTER Vadose zone soil water-filled porosity, θ_w^V (cm^3/cm^3)	ENTER Vadose zone soil organic carbon fraction, f_{oc}^V (unitless)
1.5	0.43	0.3	0.002

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1

Used to calculate risk-based soil concentration.

KLEINFELDER

RESULTS SHEET

RISK-BASED SOIL CONCENTRATION CALCULATIONS:

Indoor exposure soil conc., carcinogen (µg/kg)	Indoor exposure soil conc., noncarcinogen (µg/kg)	Risk-based indoor exposure soil conc., (µg/kg)	Soil saturation conc., C_{sat} (µg/kg)	Final indoor exposure soil conc., (µg/kg)
NA	NA	NA	1.67E+05	NA

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
NA	1.2E-07

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September, 1998

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (μg/kg)	Chemical
95476	88.5	o-Xylene

ENTER Depth below grade to bottom of enclosed space floor, L_F (15 or 200 cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Average soil temperature, T_s (°C)	ENTER Vadose zone SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined vadose zone soil vapor permeability, k_v (cm²)
15	121.92	18	SIC		

ENTER Vadose zone soil dry bulk density, ρ_b^A (g/cm³)	ENTER Vadose zone soil total porosity, n^V (unitless)	ENTER Vadose zone soil water-filled porosity, θ_w^V (cm³/cm³)	ENTER Vadose zone soil organic carbon fraction, f_{oc}^V (unitless)
1.5	0.43	0.3	0.002

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1
				Used to calculate risk-based soil concentration.	

RESULTS SHEET

RISK-BASED SOIL CONCENTRATION CALCULATIONS:

Indoor exposure soil conc., carcinogen (µg/kg)	Indoor exposure soil conc., noncarcinogen (µg/kg)	Risk-based indoor exposure soil conc., (µg/kg)	Soil saturation conc., C_{sat} (µg/kg)	Final indoor exposure soil conc., (µg/kg)
NA	NA	NA	1.60E+05	NA

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
NA	4.8E-06

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September, 1998

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (μg/kg)	Chemical
95476	7.1	o-Xylene

ENTER Depth below grade to bottom of enclosed space floor, L_F (15 or 200 cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Average soil temperature, T_S (°C)	ENTER Vadose zone SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined vadose zone soil vapor permeability, k_v (cm²)
15	121.92	18	SIC		

ENTER Vadose zone soil dry bulk density, ρ_b^A (g/cm³)	ENTER Vadose zone soil total porosity, n^V (unitless)	ENTER Vadose zone soil water-filled porosity, θ_w^V (cm³/cm³)	ENTER Vadose zone soil organic carbon fraction, f_{oc}^V (unitless)
1.5	0.43	0.3	0.002

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1

Used to calculate risk-based soil concentration.

KLEINFELDER

RESULTS SHEET

RISK-BASED SOIL CONCENTRATION CALCULATIONS:

Indoor exposure soil conc., carcinogen (µg/kg)	Indoor exposure soil conc., noncarcinogen (µg/kg)	Risk-based indoor exposure soil conc., (µg/kg)	Soil saturation conc., C_{sat} (µg/kg)	Final indoor exposure soil conc., (µg/kg)
NA	NA	NA	1.60E+05	NA

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
NA	9.4E-07

DATA ENTRY SHEET

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September, 1998

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (μg/kg)	Chemical
100414	28.15	Ethylbenzene

ENTER Depth below grade to bottom of enclosed space floor, L_F (15 or 200 cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Average soil temperature, T_S (°C)	ENTER Vadose zone SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined vadose zone soil vapor permeability, k_v (cm²)
15	121.92	18	SIC		

ENTER Vadose zone soil dry bulk density, ρ_b^A (g/cm³)	ENTER Vadose zone soil total porosity, n^V (unitless)	ENTER Vadose zone soil water-filled porosity, θ_w^V (cm³/cm³)	ENTER Vadose zone soil organic carbon fraction, f_{oc}^V (unitless)
1.5	0.43	0.3	0.002

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1

Used to calculate risk-based soil concentration.

KLEINFELDER

RESULTS SHEET

RISK-BASED SOIL CONCENTRATION CALCULATIONS:

Indoor exposure soil conc., carcinogen (μg/kg)	Indoor exposure soil conc., noncarcinogen (μg/kg)	Risk-based indoor exposure soil conc., (μg/kg)	Soil saturation conc., C_{sat} (μg/kg)	Final indoor exposure soil conc., (μg/kg)
NA	NA	NA	1.67E+05	NA

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
NA	6.5E-07

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CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (μg/kg)	Chemical
7783064	0.0654	Hydrogen sulfide

ENTER Depth below grade to bottom of enclosed space floor, L_F (15 or 200 cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Average soil temperature, T_S (°C)	ENTER Vadose zone SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined vadose zone soil vapor permeability, k_v (cm²)
15	121.92	18	SIC		

ENTER Vadose zone soil dry bulk density, ρ_b^A (g/cm³)	ENTER Vadose zone soil total porosity, n^V (unitless)	ENTER Vadose zone soil water-filled porosity, θ_w^V (cm³/cm³)	ENTER Vadose zone soil organic carbon fraction, f_{oc}^V (unitless)
1.5	0.43	0.3	0.002

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1

Used to calculate risk-based soil concentration.

RESULTS SHEET

RISK-BASED SOIL CONCENTRATION CALCULATIONS:

Indoor exposure soil conc., carcinogen (µg/kg)	Indoor exposure soil conc., noncarcinogen (µg/kg)	Risk-based indoor exposure soil conc., (µg/kg)	Soil saturation conc., C_{sat} (µg/kg)	Final indoor exposure soil conc., (µg/kg)
NA	NA	NA	2.07E+06	NA

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
NA	1.4E-04

DATA ENTRY SHEET

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CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (μg/kg)	Chemical
7783064	24.3	Hydrogen sulfide

ENTER Depth below grade to bottom of enclosed space floor, L_F (15 or 200 cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Average soil temperature, T_s (°C)	ENTER Vadose zone SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined vadose zone soil vapor permeability, k_v (cm²)
15	121.92	18	SIC		

ENTER Vadose zone soil dry bulk density, ρ_b^A (g/cm³)	ENTER Vadose zone soil total porosity, n^V (unitless)	ENTER Vadose zone soil water-filled porosity, θ_w^V (cm³/cm³)	ENTER Vadose zone soil organic carbon fraction, f_{oc}^V (unitless)
1.5	0.43	0.3	0.002

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1

Used to calculate risk-based soil concentration.

RESULTS SHEET

RISK-BASED SOIL CONCENTRATION CALCULATIONS:

Indoor exposure soil conc., carcinogen (µg/kg)	Indoor exposure soil conc., noncarcinogen (µg/kg)	Risk-based indoor exposure soil conc., (µg/kg)	Soil saturation conc., C_{sat} (µg/kg)	Final indoor exposure soil conc., (µg/kg)
NA	NA	NA	2.07E+06	NA

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
NA	5.1E-02

Appendix B. Summary of Soil Gas Survey Analytical Results

	Benzene	Toluene	Ethylbenzene	m-, p-Xylene	o-Xylene	H_2S
Samples	1,155	1,155	1,155	1,155	1,155	1,199
Detects	34	267	18	49	71	10
Frequency	3%	23%	2%	4%	6%	<1%
Minimum	0.07	0.07	0.07	0.07	0.07	0
Maximum	3.85	5.09	1.50	3.12	1.39	41.00
Average	0.24	0.18	0.29	0.25	0.16	0.11
Standard Deviation	0.66	0.35	0.39	0.45	0.18	1.25

Sources: ETI (2000), CDM (2000a), CDM (2000b)